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Fauna and biogeography of harvestmen (Arachnida: Opiliones) of the Oki Islands, Japan

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Abstract — We investigated opilionid fauna of the Oki Islands (Shimane Prefecture) in the Sea of Japan for the first time. As a result, a total of 14 species were collected from the four main islands (12, 4, 4, and 6 species from Is. Dôgo, Is. Nakanoshima, Is. Nishinoshima, and Is. Chiburi, respectively). A list of the species with some taxonomical notes is presented. Opilionid fauna of the islands may be characterized by: 1) the absence of some species which are commonly found in the San'in area of the mainland Honshu such as *Gagrellula ferruginea* Loman, and *Nelima satoi* Suzuki; 2) occurrence of some species that indicate the circum-Japan Sea distribution, such as *Leiobunum rubrum* Suzuki and *Melanopa grandis* Roewer; 3) occurrence of some species showing geographical differentiation, though there are no endemic forms at the species level; and 4) affinity to the mainland area around Mt. Daisen (Tottori Pref.) rather than mainland areas of the Shimane Prefecture in the species composition; 5) The numbers of species found on the islands generally exceed those expected from the species-area relationship in and around Japanese Islands. *Leiobunum wegneri* Šilhavý 1976 described from North Korea is newly synonymized with *Leiobunum japonicum japonicum* Müller 1914. Likewise, *Metagagrella damila* Šilhavý 1976 and *Gagrella crassitarsi* Ha et al. 2004, both originally described from Korean Peninsula, are synonymized with *Melanopa grandis* Roewer 1910. Two Korean species recently recorded under the names *Leiobunum rotundum* (Latreille 1798) and *Leiobunum rupestre* (Herbst 1799) by Ha et al. (2004, Korean Arachnology, 20: 53–71) from Korea are misidentifications of *Leiobunum japonicum japonicum* and *Odiellus aspersus* (Karsch 1881), respectively.

Key words — Oki islands, fauna, Opiliones, biogeography, species-area relationships, geographic variation, new synonymy.

Introduction

The Oki Islands, 348 km^2 as gross area, is a group of islands in the Sea of Japan located in ca. 50 km off the coast of the Shimane Peninsula of the San'in Coast (Fig. 1). The islands consist of about 180 islands and islets, and of these only the following four largest islands are inhabited: Is. Dôgo (242.6 km^2), Is. Nishinoshima (56.0 km^2) and Is. Nakanoshima (33.4 km^2), and Is. Chiburi (13.7 km^2). The Oki Suido Straight which separates the Oki islands from the Shimane Peninsula of the mainland Honshu is about 80 m in depth, and it is said that the islands had been connected to the Shimane Peninsula during the last glacial period (about 18,000 years B.P.) (Fig. 1; Yamauchi & Murakami 1999, Ota et al. 2004).

The late Dr. Ikio Sato, who worked as a cytologist of Arachnida as well as a salamander taxonomist at Hiroshima Bunrika University (now Hiroshima University), visited the islands several times from 1939 to 1942 to investigate salamanders and general fauna of the islands (Kamita 1965). He had just started also opilionid taxonomy with his student Seisho Suzuki during the period and hence one of the collecting tours in the summer of 1940 was accompanied by the late Dr. Yasunori Miyosi who also had just started taxonomical study of Japanese harvestmen (Tsurusaki 1996). They must, therefore, have collected quite a number of opilionid specimens from the islands. However, they never published any notes on the results. It is highly probable that all the collection was lost in 1945 by atomic bomb which also deprived Dr. Sato of his life. Thus, nothing has been known for the opilionid fauna of the islands.

It has been recently revealed that quite a few species of harvestmen occurring in the Chugoku Mountains, western Honshu, Japan, adjacent to the Oki Islands, show extensive geographic differentiations in various characters including chromosomes (Suzuki & Tsurusaki 1981; Suzuki 1986; Tsurusaki et al., 1991; Gorlov & Tsurusaki 2000b; Tsurusaki 2003b). Information on the character states exhibited by the populations on the Oki Islands are important to infer the directions of the character changes and processes of those geographic differentiations. As the first step of the biogeographical analyses of the Oki Islands and the

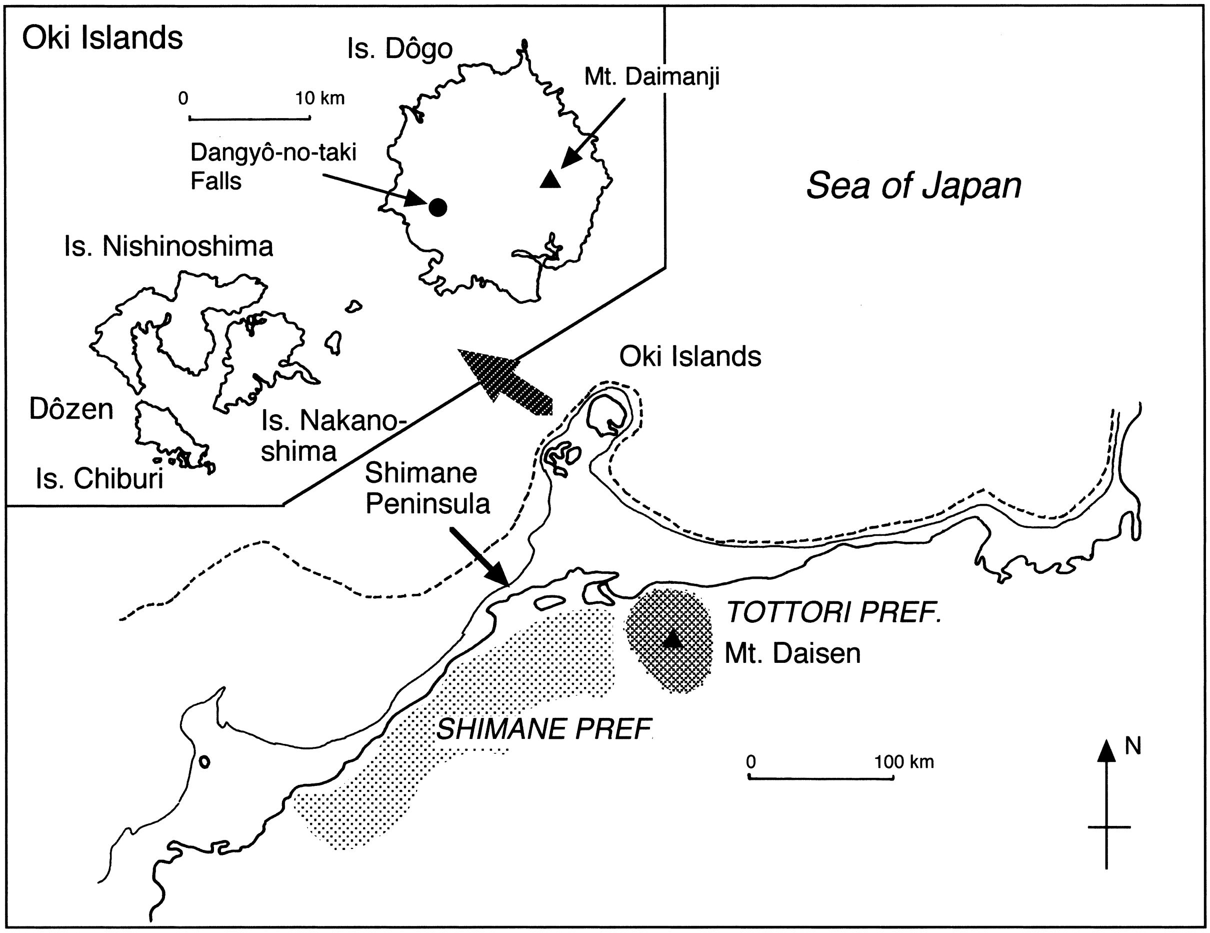

Fig. 1. Map showing locations of the Oki Islands. Coastlines are depicted with heavy-lines. Thin and dashed lines are a 100 m bathymetric line and a margin of the continental shelf, respectively (modified from Ota et al. 2004).

mainland Chugoku Mountains, we conducted some preliminary faunal surveys on the islands. We will present results of the surveys below.

List of the Species found from the Oki Islands

Collecting data are presented according to the following sequence: Locality, vegetation, altitude, date, number of specimens collected [juv.=juvenile(s), "Chrom" means the number of specimens dissected for chromosome preparation], collected by (NT=Nobuo Tsurusaki, MT=Mayumi Takanashi, NN=Nao Nagase, TS=Takashi Shimada).

Suborder Eupnoi
Superfamily Phalangioidea
Family Sclerosomatidae
Subfamily Gagrellinae

1. *Melanopa grandis* Roewer 1910
(Figs. 2–5)

Melanopa grandis Roewer 1910, p. 27. [Type locality: Japan]; 1923, p. 936; 1955, p. 105; Suzuki 1960, p. 25, fig. 7 in col. Pl. 12; 1965, p. 355, 1 fig.; 1972, p. 65, figs. 1–3; Suzuki & Tsurusaki 1983, p. 210. Tsurusaki 1982, p. 12, figs. 5–7.

Metagagrella damila Šilhavý 1976, p. 297, figs. 1–12 [Female holotype from Kuryong Falls, Kumgang-san Mountains, Korea, type depository unknown]. NEW SYNONYMY.

Gagrella crassitarsi Ha, Bae, Chun, & Kim 2004, p. 62, figs. 5 (1–6) and 6(1–6)[Holotype not designated. Mt. Odaesan, Mt. Cheonggyesan, Mt. Bukhansan, Ganghwado are shown as localities]. NEW SYNONYMY.

Specimens examined. Dôgo IS. Mt. Daimanji: Chichisugi, 400 m, 18–IX–2003, 2♂, TS; 430 m, 18–V–2004, 1 juv.(subadult), TS; Chichisugi, *Cryptomeria japonica* forest, 380–400 m, 25–V–2004, 1 juv., NT, MT & NN. Oki-Kokubunji Temple, 25 m, 5–VI–2004, 3juv., TS; Southeast entrance of Goka Tunnel, *Cryptomeria japonica* forest, 140 m, 22–VII–2004, 1♀, NT. —NAKANOSHIMA IS. Oki Shrine, 16–VII–2003, 1♀, Takeo Yamauchi. Nakasato, 18–VI–2004, 2♀, TS. Chichii, *Cryptomeria japonica* forest, 90 m, 22–IX–2004, 2♂(1 ♂ Chrom), NT, MT & NN. Toyoda, Akiya Swimming Beach, fernbrake of *Cyrtomium falcatum*, 2 m, 22–IX–2004, 1♀, NT. —NISHINOSHIMA IS. Mita: Mita Dam, 22–V–1996, 3 juv., Yukio Notsu & Tsutomu Konishi; Upper reaches of Mita Dam, 3–VII–1996, 1♀, Yukio Notsu; Lower reaches of Mita Dam, 4–

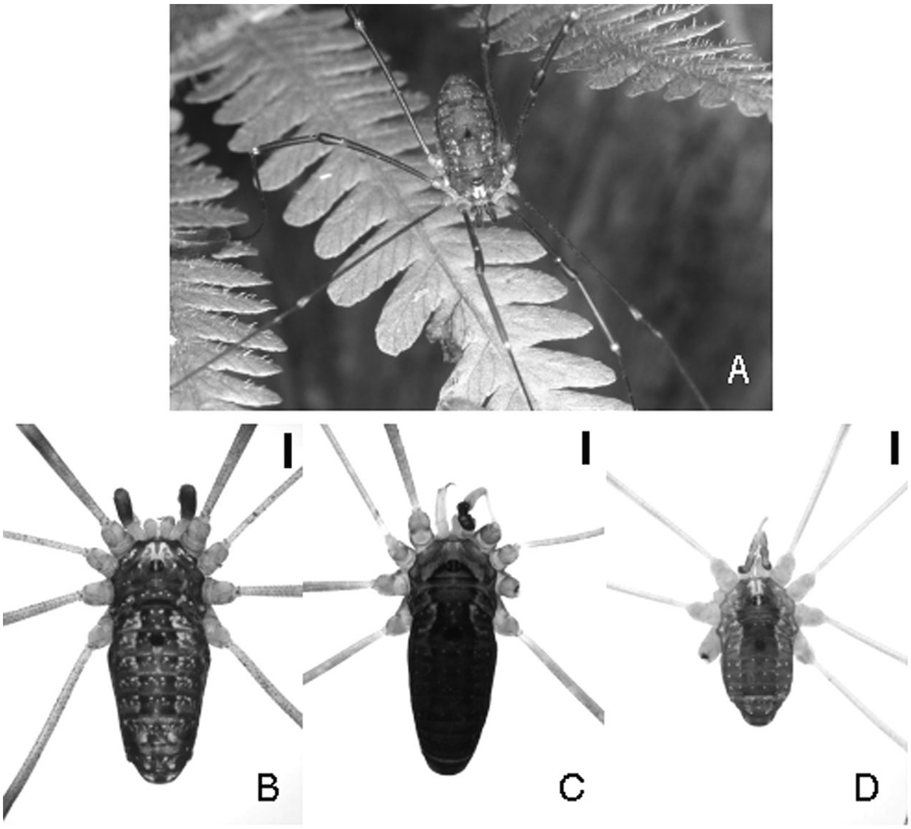

Fig. 2. *Melanopa grandis.* A, An adult female on fern at Mt. Daimanji, Is. Dôgo (July 21, 2004). B-D, male: B, Mt. Daisen race from Matengai, Is. Nishinoshima, Oki Islands; C, Honshu race from the Yakura Pass, Mizoguchi-cho, eastern Tottori Prefecture, Honshu; D, Western Setouchi race from Aohara-Hahiman-gû Shrine, Nichihara-cho, western Shimane Prefecture, Honshu. Scales = 1 mm.

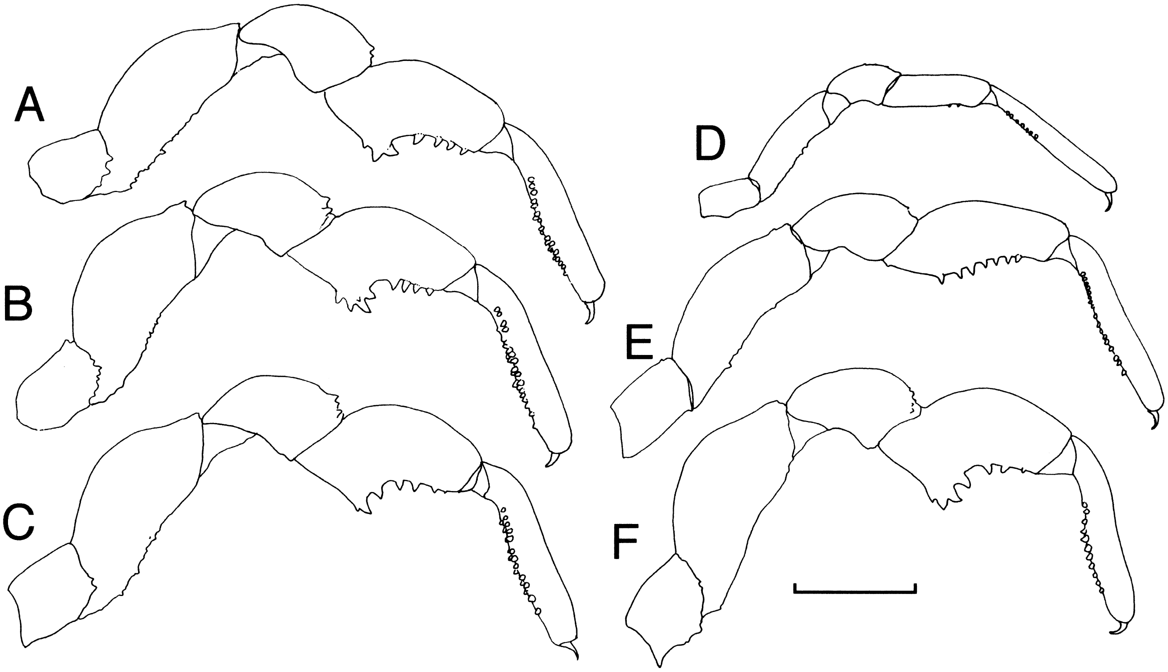

Fig. 3. Geographic variation of male palpi (left, mesal) of *Melanopa grandis.* A-D: Mt. Daisen race. E: Honshu race. F: Western Setouchi race. (A: Nibu, Is. Chiburi, Oki. B: Matengai, Kuniga Coast, Is. Nishinoshima, Oki. C: Chijii, Is. Nakanoshima, Oki. D: Amidadô, Mt. Daisen, Tottori Pref. E: the Yakura Pass, Mizoguchi-cho, Tottori Pref. F: Hidaka, Yasaka-mura, Shimane Pref.) Scale = 1.0 mm

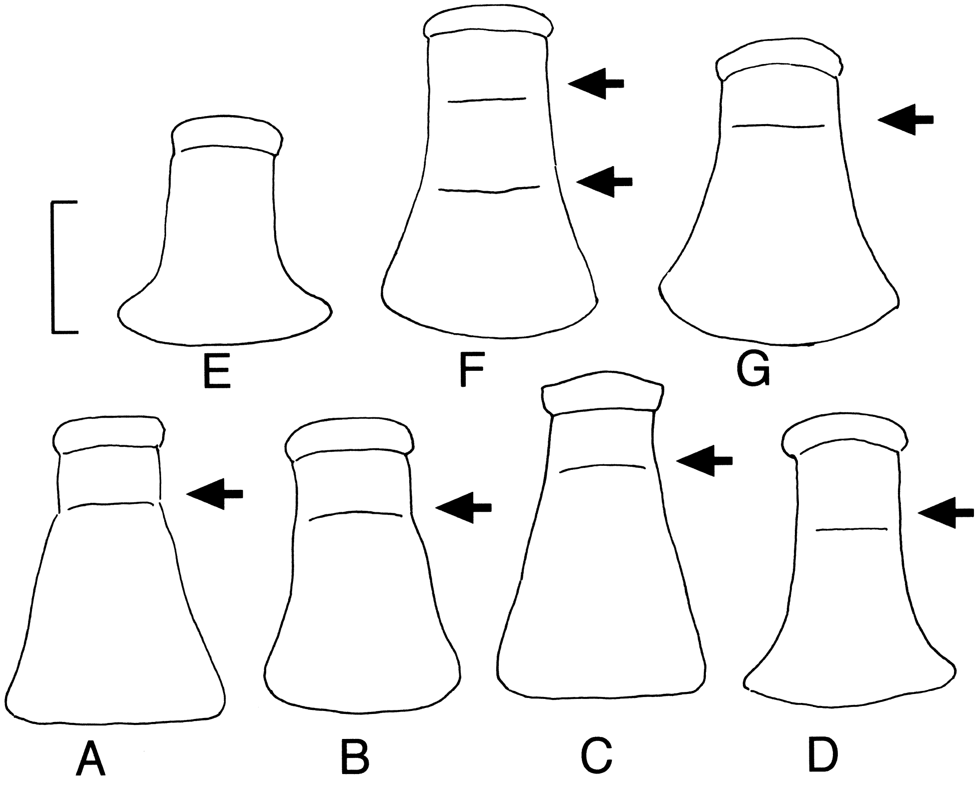

Fig. 4. Geographic variation of female genital operculum of *Melanopa grandis*. A-E: Mt. Daisen race. F: Honshu race. G: Western Setouchi race (A: Nibu, Is. Chiburi, Oki. B: Takuhi Shrine, Is. Nishinoshima. C: Akiya Coast, Is. Nakanoshima, Oki. D: Mt. Daimanji, Is. Dôgo, Oki. E: Amidadô Mt. Daisen, Tottori Pref. F: the Kamisaka Pass, Mt. Inazumi, Nichinan-cho, Tottori Pref. G: Hidaka, Yasaka-mura, Shimane Pref). Scale＝1 mm. Arrows indicate suture lines.

VII–1996, 1♀, Yukio Notsu; Miyadani Tameike of upper reaches of Mita Dam, 10–VII–1996, 1♂, Akifumi Toda; Mita Dam, 20–VI–1998, 1♂, Yukio Notsu; Mita Dam, 22–VI–1998, 1♀, Yukio Notsu. Takuhi Shrine: 3–VII–1996, 1♀, Yukio Notsu; 8–VIII–1996, 1♀, Yukio Notsu. Kuniga Beach, Matengai Viewpoint, 257 m, 21–IX–2004, 3♂(1♂ Chrom), NT, MT & NN. —CHIBURI IS. Chibu-mura, 16–IX–1992, 1♂1♀, Ken'ichiro Yodoe. Usuge, 19–IX–1993, 2♀, Ken'ichiro Yodoe. Kôri, 15–VII–2003, 1♂1♀, Takeo Yamauchi. Mt. Akahage: 15–VII–2003, 1♂1♀, Takeo Yamauchi; *Cryptomeria japonica* forest, 160 m, 20–IX–2004, 1♀, NT, MT & NN. Nibu, Ôyama Shrine, *Cryptomeria japonica* forest, 25 m, 20–IX–2004, 2♂1♀(1♂ Chrom), NT, MT, & NN.

Distribution. Hokkaido (Hakodate), Honshu, Shikoku, Kyushu, Sado Is., Oki Islands (Dôgo, Nakanoshima, Nishinoshima, Chiburi), Is. Tsushima, Korea, Fat East Russia.

Remarks. This species was found from all the four main islands of the Oki Islands. Habitats on the islands extend over a wide range from seashore fernbrake, grassland meadow, to the mountain forest.

This species shows extensive geographic variation in various characters such as body size, leg length, male palp, or female genital plates (Suzuki 1972). The species on main islands of Japan can be divided into three geographic races on the basis of those characters: Western Setouchi race (Kyushu, Shikoku, and westernmost part of Honshu), Honshu race (most part of Honshu, and southern part of Hokkaido), and Mt. Daisen race (small area around Mt. Daisen, Tottori Prefecture, Honshu) (Fig. 5). Populations from all the four main islands of the Oki Islands share 1) thickened male palpi, each with a ventral spur on the tibia (Fig. 3A–C) and 2) 2-partitioned genital operculum (Fig. 4A–D). These character states are the same as those found in populations of Mt. Daisen and its vicinities (Figs. 3F and 4G) and hence they are safely designated as the Daisen race. It is worth noted that the incrassate male palp with a ventral spur on tibia is also shared by populations in the Korean Peninsula and a part of populations in the Noto Peninsula of central Honshu (Fig. 5).

However, geographic range of the character state is not congruent with that of the female genital operculum with 2-partition. This state (2-partition) in the female genital operculum can be seen only in the southern part of the Is. Tsushima, which lies between the Korean Peninsula and Kyushu, except for the areas occupied by the Mt. Daisen race (In Korean populations females exhibit 3-partition as in Honshu race (Fig. 4F).

Recently, Ha et al. (2004) described a new species of Gagrellinae under the name of *Gagrella crassitarsi* from

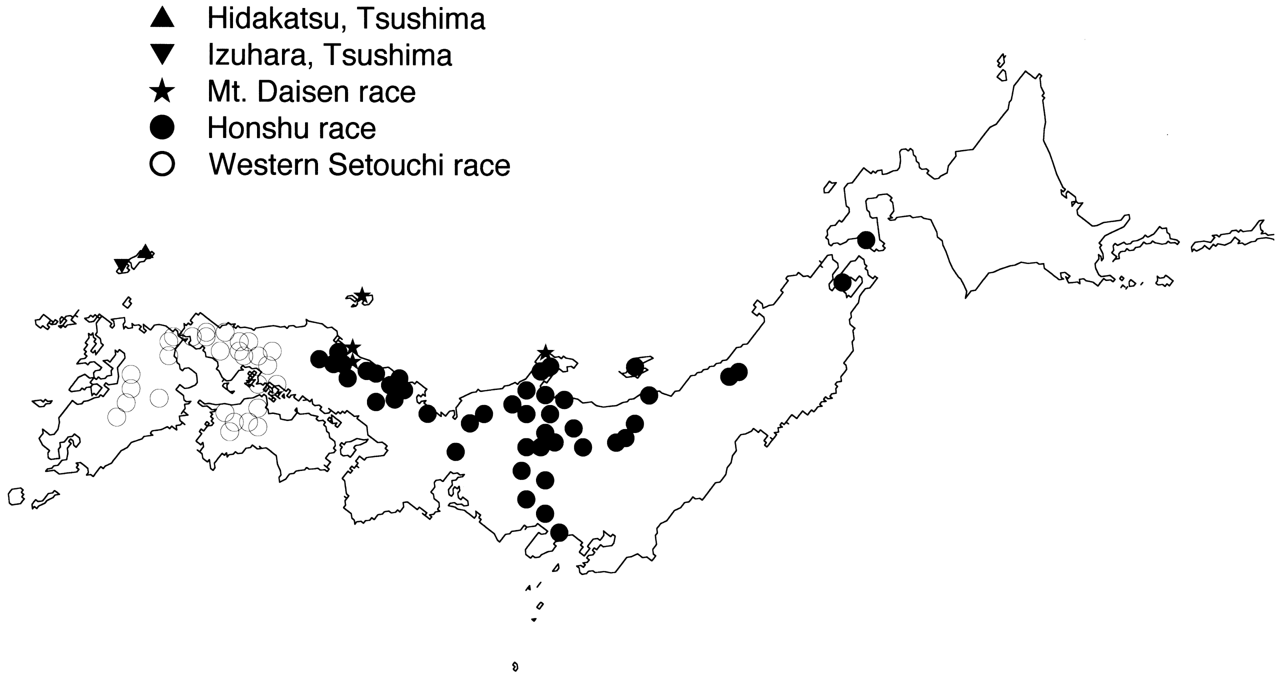

Fig. 5. Distribution of *Melanopa grandis* in Japan.

South Korea (Yekgol, Sujeong-gu, Seongnam-si, Gyeonggi-do; Muak-dong, Jongno-gu, Seoul; Jeondeungi-gogae, Gyondong-myeon, Ganghwa-gun, Incheon; Jinbu-myeon, Pyeongchang-gun, Gangwon-do; Yekgol, Sujeong-gu, Seongnam-si, Gyeonggi-do) without any designation of the type specimen nor type locality. Description of the species with 12 photos perfectly matches with Korean populations of *Melanopa grandis* (Suzuki 1972). Furthermore, *Metagagrella damila* described by Šilhavý 1976 based on a female from Kuryon Falls, Kumgang-san Mountains of North Korea can also be successfully recognized to be conspecific with *Melanopa grandis*.

Details of the geographic variation with full description of the species will be published elsewhere.

2. *Psathyropus tenuipes* L. Koch 1878

Psathyropus tenuipes L. Koch 1878, p. 785. [Type: Japan; in the NHMW]; Roewer 1923, p. 1088; Crawford 1992, p. 40; Tsurusaki 2003a, p. 6, fig. 1K; Tsurusaki & Shimada 2004, p. 365.

Gagrella japonica Roewer 1910, p. 89; 1923, p. 992; 1954, p. 225; Suzuki 1960, p. 25.

Metagagrella tenuipes tenuipes: Suzuki 1973, p. 250, figs. 96–101. 7 in plate II; Tsurusaki 1993; Gorlov & Tsurusaki 2000a, p. 209; 2000c, p. 349.

Gagrella japonica yezoensis Suzuki 1949, p. 210; 1965, p. 354; Roewer 1954, p. 225.

Metagagrella tenuipes yezoensis: Suzuki & Tsurusaki 1983, p. 210, fig. 11.

Specimens examined. DÔGO IS. (Goka-mura) Fuku-ura, Fuku-ura Tunnel, 3 m, 26–V–2004, 2 juv., NT, MT, & NN. (Tsuma-mura) Kamaya, Sudokosan Beach (Yana-no-Matsubara), 1 m, 22–VII–2004, 9♂8♀13juv.(9♂1 juv.(♀) Chrom), NT. —NAKANOSHIMA IS. Toyoda, Akiya Swimming Beach: 29–VI–2004, 13♂5 juv.(13♂Chrom), TS; fernbrake of *Cyrtomium falcatum*, 2 m, 22–IX–2004, 13♂15♀, NT, MT & NN. —NISHINOSHIMA IS., Kuniga Beach, Matengai Viewpoint, 257 m, 21–IX–2004, 1♂, NT, MT & NN. Hashi, Benten-bana Point, 2 m, 21–IX–2004, 5♂2♀(5♂ Chrom), NT, MT & NN. —CHIBURI IS. Usuge, 15–VII–2003, 2 juv., Takeo Yamauchi. Tataku, Chibu Dock, 2 m, 20–IX–2004, 16♂19♀(12♂Chrom), NT, MT & NN. Sekiheki, 15–VII–2003, 1 juv., Takeo Yamauchi.

Distribution. Hokkaido, Honshu, Shikoku, Kyushu, the Oki Islands.

Remarks. This species is halophilic and inhabits sandy beach accompanied by abrasion cliffs. The species was found from all the four main islands of the Oki islands. We surveyed chromosomal variation of the species for four populations covering all the four main islands, since this species bears numerous B-chromosomes and the number varies geographically (Tsurusaki 1993; Gorlov & Tsurusaki 2000a, 2000c; Tsurusaki & Shimada 2004). Details of the results will be reported elsewhere.

3. *Systenocentrus japonicus* Hirst 1911

Specimens examined. DÔGO IS. Mt. Daimanji: 490 m, 11–VI–2004, 1♂2♀, TS; 450 m, 25–V–2004, 17♂2♀,TS. Nakayama Tunnel to entrance of Tsubame, 100 m, 3–V–1980, 3♂3♀, N.

Doi & O. Tominaga.

Distribution. Honshu, Shikoku, Kyushu, Is. Dôgo.

Remarks. This is a small-sized (ca. 2.5–3 mm in body length) gagrellid which inhabits debris and soil litter on the forest floor or on herb. The species bears five abdominal spines longitudinally lined on the abdomen. In addition to the five abdominal spines, specimens from Shikoku and Chugoku District of Honshu excluding Yamaguchi Prefecture bear an additional spine on the second thoracic tergite; which is designated as 6-spined form (Suzuki & Tsurusaki 1981). All the specimens from the Is. Dôgo populations were also 6-spined.

4. *Gagrellopsis nodulifera* Sato & Suzuki 1939

Specimens examined. DÔGO IS. Mt. Daimanji, Chichisugi: *Cryptomeria japonica* forest, 380–400 m, 25–V–2004, 2♂(All Chrom), NT, MT & NN; Roadside gutter, 400 m, 25–V–2004, 1♂, TS. Mt. Washigamine, Nakadani, Tokage-iwa Path, 320 m, 25–V–2004, 1♂(Chrom), NT, MT & NN. Dangyô-no-taki Falls, 270–300 m, 26–V–2004, 1♂(Chrom), NT, MT & NN.

Distribution. Honshu (Yamagata Pref. and southward), Shikoku, Kyushu, Is. Dôgo.

Remarks. This species was found only from Is. Dôgo in the Oki Islands. It is unlikely that the species occurs in the other islands where mountains are generally low (mostly less than 300 m high), because the species is usually found only from mountainous areas above 400 m in the Chugoku Mountains.

Subfamily Leiobuninae

5. *Nelima nigricoxa* Sato & Suzuki 1939

Specimens examined. DÔGO IS. Mt. Daimanji, Chichisugi: 400 m, 23–IX–2003, 1♀, TS; 20–X–2003, 1♀, TS; 10–XI–2003, 1♂, TS; on Hydrangea petiolaris, 400 m, 1–VI–2004, 2 juv., TS; 21–VII–2004, 4♂2♀(All Chrom), NT, MT, NN. Nakadani, 300–310 m, 4–X–2004, 1♀, TS. Southeast entrance of the Goka Tunnel, *Cryptomeria japonica* forest, 140 m, 22–VII–2004, 4♂(2♂ Chrom), NT. Ôku, 31–X–2003, 1♀, TS. Dangyô-no-taki Falls: 270–300 m, 26–V–2004, 2 juv., NT, MT & NN; 280–300 m, 22–VII–2004, 7♂17♀4 juv. (2♂ Chrom), NT, NN & MT. —NISHI-NOSHIMA IS. Mita Dam, 22–VI–1998, 1 juv. Yukio Notsu; 29–VI–1998, 1♂, Yukio Notsu.

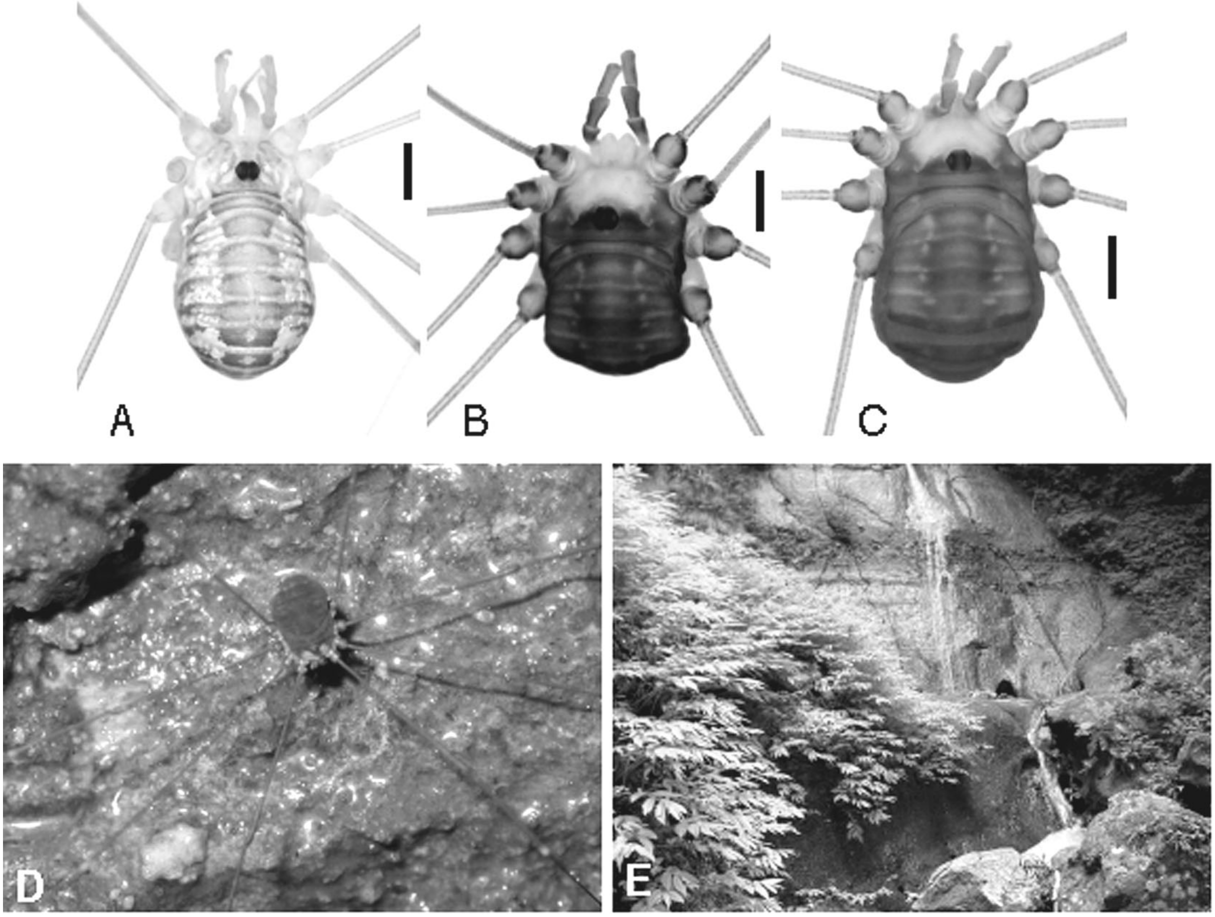

Fig. 6. Two interesting species of *Leiobunum* from Is. Dôgo, Oki Islands. A, *Leiobunum* sp. aff. *hiraiwai*, female from a *Cryptomeria japonica* forest near southeastern entrance of the Goka Tunnel. B-D, *L. rubrum* from Dangyô-no-taki Falls: B, male, C, female, D, a male resting on a wet wall of a rock in a cascade. E, A cascade where *L. rubrum* resides in the Dangyô-no-taki Falls area.

Distribution. Honshu (Chiba Pref. and westward), Shikoku, Kyushu, Is. Dôgo, Is. Nishinoshima.

Remarks. We prepared several chromosome slides using several males from three sites in Dôgo Island (Mt. Daimanji, Dangyô-no-taki Falls, and Goka Tunnel). They showed diploid chromosome number 2n=22. This chromosome number is different from those exhibited by populations in the Chugoku Mountains in the mainland Honshu (Tsurusaki 2003b). Details of the results will be reported elsewhere.

6. *Leiobunum rubrum* Suzuki 1966 (Figs. 6B–D, 7)

Leiobunum rubrum Suzuki 1966, p. 166, figs. 3G–J, 4. [Mt. Sogri, Chungpuk, Korea; 1973, p. 258, figs. 112–117, fig, 1 in pl. III; 1976, p. 209, figs. 308–309.

Specimens examined. DÔGO IS. Dangyô-no-taki Falls: 270–300 m, 26–V–2004, 1 juv., NT, MT & NN; 300 m, 22–VII–2004, 5♂4♀(2♂ Chrom), NT. Nakadani, Furusato-no-mori, *Cryptomeria japonica* forest, 120 m, 25–V–2004, 2 juv., NT.

Other specimens examined. FUKUI PREF. Onyû-gun, Kaminaka-cho, Tentokuji Temple, Uriwari-no-taki Falls, 30–IX–2002, 1♂, NT. —YAMAGUCHI PREF. Toyoura-gun, Toyoda-cho, Mt. Gesan, Tokusen-no-taki Falls, 180 m, 4–X–1995, 1♂3♀, NT.

Distribution. Honshu (Ishikawa, Fukui, Yamaguchi prefectures), Is. Dôgo, Is. Tsushima, Is. Yakushima, Korea.

Remarks. This species, which was originally described from Korea, is a rare species and there have been only three records in Honshu (Wajima in the Noto Peninsula, Ishikawa, Pref. reported in Suzuki 1973 & 1976; and Uriwari-no-taki Falls in Kaminaka-cho, Fukui Pref., and Tokusen-no-taki Falls in western part of Yamaguchi Pref. (Fig. 7). No records have been available from the San'in District. We found this species in two sites in Dôgo Island. Both the sites were riversides where a spray of water generated from falls and cascades moistens air. Localities in Yamaguchi and Fukui prefectures, both were found by one of us (NT), exhibited similar environment near falls. Thus this species seems to have strong affinities with dump and darkened environments along mountain streams.

7. *Leiobunum* sp. aff. *hiraiwai* (Sato & Suzuki 1939) (Fig. 6A)

Specimens examined. DÔGO IS. Nakadani, on blooms of *Viburnum sieboldii* var. *obovatifolium*, 295 m, 1–V–2004, 2 juv., TS; Mt, Daimanji, Chichisugi: 380–400 m, 25–V–2004, 6 juv., NT, MT & NN; 400 m, 1–VI–2004, 3 juv., TS. Southeast entrance of Goka Tunnel, *Cryptomeria japonica* forest, 140 m,

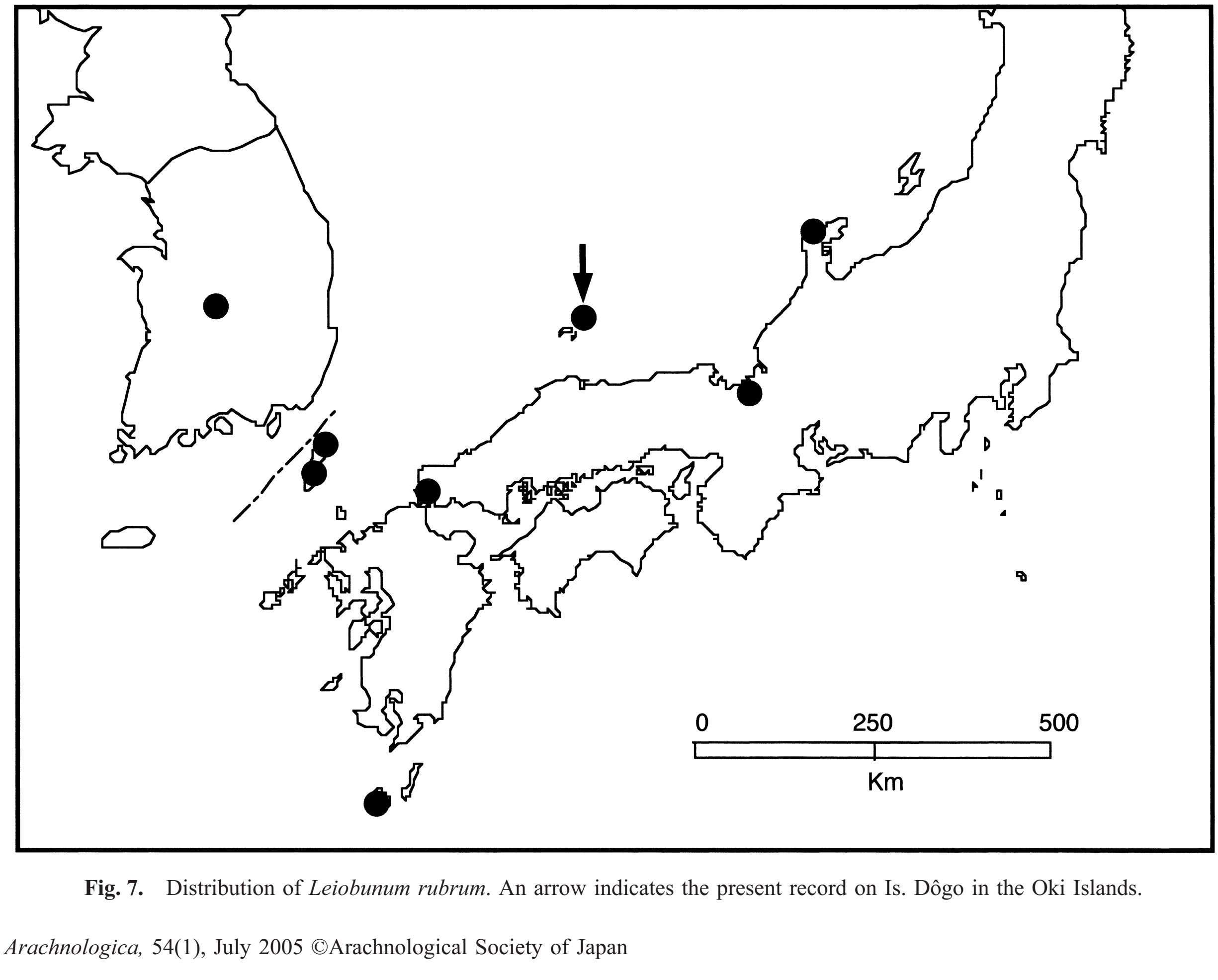

Fig. 7. Distribution of *Leiobunum rubrum*. An arrow indicates the present record on Is. Dôgo in the Oki Islands.

22–VII– 2004, 1♀, NT. Dangyô-no-taki Falls, 270–300 m, 26–V–2004, 4 juv., NT, MT & NN.

Remarks. General appearance of the body and distally swollen palpal patella and tibia of juvenile and female specimens of the species testifies this species is undoubtedly a member of the *curvipalpe*-group of *Leiobunum*. However, species identification of the harvestmen belonging to the group is rather difficult unless they are accompanied by males. As the species of the present specimens, two most probable candidates are *L. hiraiwai* (Sato & Suzuki 1939) and *L. montanum* Suzuki 1953 both of which are widely distributed in western Japan though their distributional ranges are mutually exclusive (Suzuki 1976; Tsurusaki & Okada 2000). Of these, distributional range of the latter is limited to central and eastern part of Tottori Prefecture including Mt. Daisen in the Chugoku Mountains. On the other hand, *L. hiraiwai* occupies a wide distributional range from Mt. Mihira, which locates just south of Mt. Daisen, to Yamaguchi Prefecture (Tsurusaki & Okada 2000). Geographical location of the Oki Islands, which is somewhat closer to the ranges occupied by *L. hiraiwai*, favors the idea that this species is *L. hiraiwai*. However, no reliable conclusion cannot be made for the species identification before males of the species are available.

Species belonging to the group usually inhabits mountainous areas accompanying beech (*Fagus crenata*) forest or subalpine coniferous forest. *Leiobunum montanum* and *L. hiraiwai* are also usually distributed in the mountainous areas above 700 m in the Chugoku Mountains (Tsurusaki 1985), though the lower limit of the ranges descends to ca. 400 m in the northeastern part of Tottori Prefecture. Thus, it is noteworthy that this species was found even from the areas as low as 140 m in the island (Goka Tunnel). It might be possible that absence of some common species such as *Gagrellula ferruginea* in the Islands enables expansion of the distributional range of *L.* sp. aff. *hiraiwai* to the lower part of the island.

8. *Leiobunum japonicum japonicum* Müller 1914

Liobunum japonicum Müller 1914, p. 627; Roewer 1923, p. 894; Suzuki 1949, p. 18; 1958, p. 67, figs. 1–2.

Leiobunum japonicum: Roewer 1957, p. 343; Suzuki 1960, 22.

Leiobunum japonicum japonicum: Suzuki 1976, p. 204, figs. 161–167; 1986, p. 27, fig. 32; Suzuki & Tsurusaki 1983, p. 212; Tsurusaki 1985, p. 39; Tsurusaki & Holmberg 1986, p. 123, fig. 1.

Leiobunum wegneri Šilhavý 1976, p. 296, figs. 1–5 [Female holotype from Kuryong Falls, Kumgang-san Mountains, North Korea]. NEW SYNONYMY.

Leiobunum rotundum (nec): Ha, Bae, Chun & Kim 2004, p. 59, fig. 3 (1–6).

Specimens examined. DÔGO IS. Uzuki, 20 m, 10–VIII–2004, 1♀, Kei Ichisawa. Mt. Daimanji, 28–VII–2002, 1♂, Takeo Yamauchi. Fukuura, 18–IX–1993, 1♀, Ken'ichiro Yodoe. Mt. Ômine (northernmost), in roadside gutter, 8–XI–2003, 1♀, TS. Ôtsuku, 115 m, 6–IX–2004, 3♂4♀, TS. —NAKANOSHIMA IS. Kinkôji Temple, 140 m, 22–IX–2004, 12♂1♀(3♂ Chrom), NT, MT & NN. Chichii, *Cryptomeria japonica* forest, 90 m, 22–IX–2004, 1♂2♀(1♂ Chrom), NT, MT & NN. Hobomi, Seisui-ji Temple, Tenkawa-no-mizu, 30 m, 22–IX–2004, 2♀, NT, MT & NN. Toyoda, Akiya Port, 2 m, 22–IX–2004, 1♀, NT, MT & NN. —NISHINOSHIMA IS. Takuhi Shrine: 3–VII–1996, 1 juv., Yukio Notsu; 8–VIII–1996, 1 juv., Yukio Notsu; 240–320 m, 21–IX–2004, 30♂10♀(3♂ Chrom), NT, MT & NN. Kuniga Beach, Matengai Viewpoint, 257 m, 21–IX–2004, 4♂7♀, NT, MT & NN. —CHIBURI IS. Mt. Akahage, *Cryptomeria japonica* forest, 160 m, 20–IX–2004, 32♂14♀, NT, MT & NN. Summit of Mt. Akahage, grassland, 324 m, 20–IX–2004, 2♂4♀, NT, MT & NN. Mt. Akahage, 15–VII–2003, 1 juv., Takeo Yamauchi. Nibu: *Thujopsis dolabrata* forest, 30 m, 20–IX–2004, 7♂1♀(3♂ Chrom), NT, MT & NN; Ôyama Shrine, *Cryptomeria japonica* forest, 25 m, 20–IX–2004, 5♂9♀, NT, MT & NN. Tataku, Chibu Dock, 2 m, 20–IX–2004, 1♀, NT.

Distribution. Hokkaido, Honshu, Shikoku, Kyushu, Oki Islands, Is. Tsushima, Korea.

Remarks. This species was found from most sites surveyed in the Oki Islands in 2004. The species tends to be more frequently found in meadows, roadsides of the secondary forests or in sparse woodlands rather than dense forests in the mountainous area. Traditionally active pasturage in the Oki Islands may generate habitats suitable for this species, through grassland maintenance and expansion of the secondary forest.

Šilhavý (1976) described a new species of *Leiobunum* under the name *L. wegneri* on the basis of a female from Kuryong Falls, Kumgang-san Mountains, North Korea. Description and all the illustrations of the species presented perfectly correspond to all the characteristics of *Leiobunum japonicum japonicum* Müller 1914. Thus we safely conclude that *L. wegneri* is a junior synonym of the latter.

Ha et al. (2004) recorded "*Leiobunum rotundum* (Latreille 1789)" from three localities of South Korea (Yekgol Sujeong-gu, Seongnam-si, Gyeongii-do; Jeongneung-dong, Seongbuk-gu, Seoul; and Jeondeungi-gogae, Gyodong-myeon, Ganghwa-gu, Incheon). However, description of the species with 6 photographs of the species presented (fig. 3 in Ha et al. 2004) attests that this species is not a European species "*Leiobunum rotundum* (Latreille 1789)" but *L. japonicum japonicum*.

Family Phalangiidae

9. *Odiellus aspersus* (Karsch 1881)

Lacinius aspersus Karsch 1881, p. 35; Roewer 1911, p. 599.

Oligolophus aspersus: Roewer 1912, p. 54; 1923, p. 722; 1957, p. 326; Suzuki 1986, p. 25, figs. 28–29; Suzuki & Tsurusaki 1983, p. 205, fig. 8.

Odiellus aspersus: Staręga 1978, p. 212; Tsurusaki 2003a, p. 6, fig. 1D.

Leiobunum rupestre (nec.): Ha, Bae, Chun, & Kim 2004, p. 60, fig. 4 (1–6)

Specimens examined. DÔGO IS. Mt. Daimanji, Chichisugi: 400 m, 23–IX–2003, 2♀, TS; 550 m, 23–IX–2003, 1♂, TS; *Cryptomeria japonica* forest, 380–400 m, 25–V–2004, 2 juv. NT, MT & NN; 21–VII–2004, 2♂1♀1 juv.(2♂ Chrom), NT, MT & NN; *Cryptomeria japonica* forest, 400 m, 11–VI–2004, 10juv., TS; 490 m, 1–IX–2004, 2♀, TS; 500 m, 4–X–2004, 1♀, TS; summit, 28–VII–2002, 1♀, Takeo Yamauchi. Nakadani, 300–310 m, 4–X–2004, 1♂, TS. Mt. Washigamine, 450–550 m, 24–VI–2004, 3 juv. TS.

Distribution. Sakhalin, Hokkaido, Honshu, Shikoku, Kyushu, Korea.

Remarks. It seems that this species is confined to higher altitudes in Mt. Daimanji in Dôgo Island in the Oki Islands.

Specimens recently reported from three localities of South Korea (Gyeongigi-do, Namyangju-si; Yeongwol-eup, Yeongwol-gun, Gangwon-do; and Wido, Wido-myeon, Buan-gun, Jeollabuk-do) by Ha et al (2004) under the name of *Leiobunum rupestre* (Herbst 1799) are undoubtedly of this species. *Leiobunum rupestre* is a European species (Martens 1978) and it is incredible that opilionid fauna of the northeast Asia contains such species unless it was artificially introduced.

Superfamily Caddoidea
Family Caddidae
10. *Caddo agilis* Banks 1892

Specimens examined. DÔGO Is. Mt. Daimanji, Chichisugi, *Cryptomeria japonica* forest, 380–400 m, 25–V–2004, 1 juv., NT, MT & NN.

Distribution. Hokkaido, Honshu, Shikoku, Is. Dôgo. eastern part of North America.

Remarks. Paucity of the records of this species from the Oki Islands is probably due to its small body size (ca. 2.5 mm) and relatively short life span, adults emerging only from June to July (Tsurusaki 2003a); It is highly probable that this species is also distributed in the islands of the Dôzen area.

Suborder Dyspnoi
Superfamily Ischyropsalidoidea
Family Sabaconidae
11. *Sabacon imamurai* Suzuki 1964

Specimens examined. DÔGO IS. Mt. Daimanji, Chichisugi, in roadside gutter, 400 m, 25–V–2004, 1 juv., TS. Dangyô-no-taki Falls, 270–300 m, 26–V–2004, 1 juv. NT, MT & NN.

Distribution. Hokkaido, Honshu, Kyushu.

Remarks. This species overwinters as eggs and adults emerge in late autumn (Tsurusaki 2003a). No adult specimens have been available from the islands.

In the Chugoku Mountains of the mainland Honshu, a total of five species have been known in the genus *Sabacon* (*S. imamurai, S. akiyoshiensis, S. dentipalpis, S. pygmaeus,* and *S. makinoi sugimotoi*) (Suzuki 1986; Tsurusaki unpublished data). Of these, *S. imamurai* and *S. pygmaeus* Miyosi 1942 are most widespread in the area. The latter has not been recorded from the Oki Islands, though occurrence of the species in the Islands is probable.

Suborder Laniatores Thorell
Family Phalangodidae Simon
12. *Proscotolemon sauteri sauteri* Roewer 1916

Specimens examined. CHIBURI IS. Sekiheki, 25–III–1989, 3 ♀, Shuji Fukui.

Distribution. Honshu (southern part of the Kanto District and westward), Shikoku, Kyushu, Is. Chiburi.

Remarks. Due to its small size (body length ca. 1mm), it is usually difficult to collect this species without the use of Tullgren funnel. The species is expected to be collected also in other three main islands of the Oki Islands, if intensive survey of soil harvestmen were made using a sifter or a Tullgren funnel.

Family Epedanidae
13. *Pseudobiantes japonicus* Hirst 1911

Specimens examined. DÔGO IS. Ôku, 19–XI–2001, 4♀, Takeo Yamauchi. Mt. Daimanji, Chichisugi, *Cryptomeria japonica* forest, 380–400 m, 25–V–2004, 1♂4♀1juv., NT, MT & NN. Dangyô-no-taki Falls, 270–300 m, 26–V–2004, 1♂1♀, NT, MT & NN. —NAKANOSHIMA IS. Chichii, *Cryptomeria japonica* forest, 90 m, 22–IX–2004, 2♂2♀, NT, MT & NN. CHIBURI IS. Nibu, *Cryptomeria japonica* forest near Ôyama Shrine, 25 m, 20–IX–2004, 1♂4♀, NT.

Distribution. Honshu (Chiba Pref. and westward), Shikoku, Kyushu.

Remarks. This species is common in western Japan and can be found beneath stones, fallen logs, and leaf litter on the forest floor. It is expected that the species is widespread also in the islands, though no specimen has been found in Is. Nishinoshima.

14. *Epedanellus tuberculatus* Roewer 1911

Specimens examined. CHIBURI IS. Nibu, Ôyama Shrine, *Cryptomeria japonica* forest, 25 m, 20–IX–2004, 2♂1♀, NT.

Distribution. Honshu (Fukui Pref. and westward), Shikoku, Kyushu, Is. Chiburi, Is. Yaku, Is. Tanegashima.

Remarks. This species closely resembles *Pseudobiantes japonicus*, though it is much larger in body size (4.5–7.0 mm) than the latter (3.5–4.0mm). The species is far less abundant than *P. japonicus* though their distributional ranges widely overlap one another. Occurrence of the species in Chiburi Island is noticeable, because records of the species in the San'in area of the Chugoku District are extremely scarce.

General remarks

1. Species composition

Table 1 summarizes opilionid species recorded from four

Table 1. Records (+) of opilionid species in four main islands (Dôgo, Nakanoshima., Nishinoshima, Chiburi) of the Oki Islands and adjacent areas (Shimane Peninsula, Trunk of Shimane Prefecture excluding Shimane Peninsula, and the Mt. Daisen area). Naka＝Nakanoshima Is., Nishi＝Nishinoshima Is.

Species	Dôgo	Naka	Nishi	Chiburi	Shimane Pen.	Tr. Shimane	Mt. Daisen
Systenocentrus japonicus	+				+	+	+
Psathyropus tenuipes	+	+	+	+	+	+	+
Gagrellula ferruginea					+	+	+
Melanopa grandis (Daisen race)	+	+	+	+			+
Melanopa grandis (Honshu race)						+	
Gagrellopsis nodulifera	+				+	+	+
Nelima nigricoxa	+		+		+	+	+
Nelima satoi					+	+	+
Leiobunum japanense japonicum						+	+
Leiobunum hiraiwai[1)]	+					+	
Leiobunum montanum							+
Leiobunum rubrum	+						+
Leiobunum japonicum japonicum	+	+	+	+	+	+	+
Odiellus aspersus	+				+	+	+
Caddo agilis	+					+	
Nipponopsalis abei abei						+	+
Sabacon pygmaeus							+
Sabacon makinoi						+	
Sabacon imamurai	+					+	+
Sabacon dentipalpis					+	+	+
Sabacon akiyoshiensis						+	
Nippononychus japonicus						+	
Metanippononychus daisenensis				+			
Proscotolemon sauteri sauteri				+			
Pseudobiantes japonicus	+	+		+			
Epedanellus tuberculatus				+			
Total number of species	12	4	4	6	9	22	17

1) *Leiobunum* sp. aff. *hiraiwai* in Dôgo Is. was treated here as conspecific with *L. hiraiwai.*

main islands of the Oki Islands and those from three adjacent areas (also see Fig. 1). The numbers of species confirmed for Islands Dôgo, Nishinoshima, Nakanoshima, and Chiburi, were 12, 4, 4, and 6, respectively. These seem to cover 70 to 80 percent of the number that is finally expected to occur in these islands. It is noteworthy that *Gagrellula ferruginea* (Loman 1902)(Sclerosomatidae, Gagrellinae) and *Nelima satoi* Suzuki 1944 (Leiobuninae), both are among the commonest in the mainland Honshu, seems to be absent from any of the four islands of the Oki Islands. Likewise, we failed to find *Nelima nigricoxa*, which is another commonest species of harvestmen, in two of the Dôzen Islands (Is. Nakanoshima and Is. Chiburi). On the other hand, we found two species of which we had not expected their occurrence in the Oki Islands prior to the present survey. They are *Leiobunum rubrum* and *Leiobunum* sp. aff. *hiraiwai*, both from Is. Dôgo. It seems that these two species and two other species *Gagrellopsis nodulifera* and *Odiellus aspersus* are confined to Is. Dôgo where the highest peak (Mt. Daimanji) reaches 608 m in altitude.

Of the three species found from all the four main islands (*Psathyropus tenuipes, Melanopa grandis*, and *Leiobunum japonicum*), *M. grandis* is remarkable for its endemism. In structure of both the male palp and the female genital plate, populations of the Oki Islands of this species are quite different from the Honshu race, which is found in the mainland part of Shimane Prefecture, and show complete affinities to the Mt. Daisen race which inhabits in and around Mt. Daisen of Tottori Prefecture (Fig. 5). The spur-like protuberance of the male palpal tibia which characterizes Mt. Daisen race (including the Oki populations) is also shared by populations in Korean Peninsula and a population in the Noto Peninsula (Ishikawa Prefecture) of Honshu (Suzuki 1972; see also Fig. 5). This geographical pattern suggests direct immigration of the species from Korean Peninsula to the Oki Islands and Mt. Daisen areas (plus a part of the Noto Peninsula) across the Sea of Japan, though the character states in the female genital plate do not show the same pattern of geographic variation. Some influence of Korean fauna to the Oki Islands across the Sea of Japan is also suggested by the occurrence of *Leiobunum rubrum* in which the known records of the species from Honshu seems to be confined to the areas along the San'in and Hokuriku Coasts of Sea of Japan (Fig. 7). Phylogeographical studies using some molecular markers are required to confirm the possibility.

Using data presented in Table 1, we calculated species similarity indices between every two pairs of the areas. Species similarity indices used are Jaccard's coefficient (C_J) and Dice's coefficient (C_D), calculated by the following equations, where a and b are the number of species recorded for areas A and B, respectively, and c the number of species shared by areas A and B (Brown & Lomolino 1998):

$$C_J = c/(a+b-c)$$

$$C_D = 2c/(a+b)$$

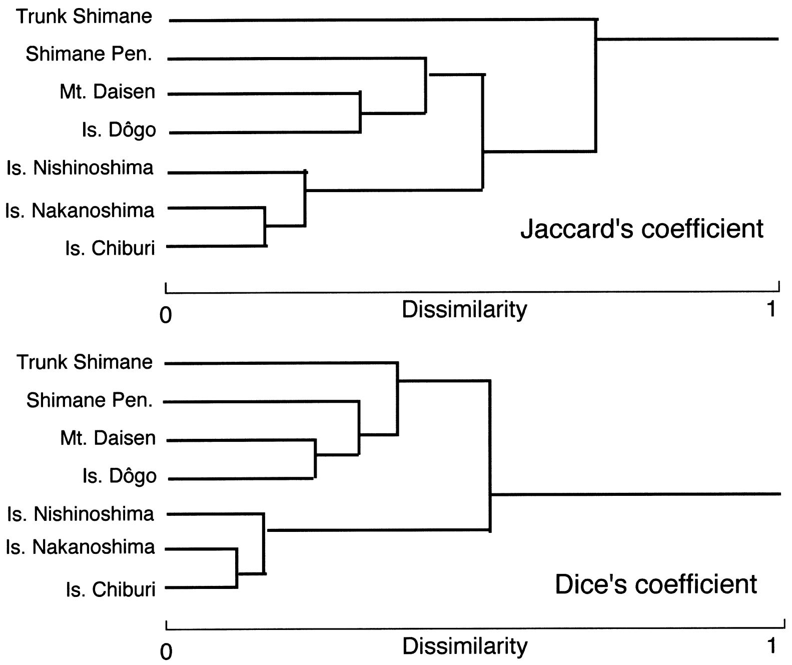

Fig. 8. Clustering (UPGMA) of islands in the Oki Islands and adjacent areas based on two different similarity indices.

Figure 8 represents UPGMA dendrograms generated by cluster analyses performed for each of those data sets aided by Systat ver. 5.2 (1992). A clade which consists of thee islands of Dôzen with the topological order ((Is. Chiburi, Is. Nakanoshima) Is. Nishinoshima) was generated in both the dendrograms. On the other hand, opilionid fauna of Is. Dôgo showed largest and second largest affinities to Mt. Daisen area and the Shimane Peninsula, respectively.

2. Species-area relationship

It is well known that there is a relationship which can be expressed by the following power function between the area of island (A) and the number of species (S) found on the island: $S=CA^z$ ($C=$fitted constant; $z=$another fitted constant that represents the slope when both S and A are plotted against logarithmic scales)(Brown & Lomolino 1998). Figure 9 shows the species-area relationship of the four main islands of the Oki Islands. Also shown are data on the other major islands along the mainland Japan (Tsushima, Kyushu, Shikoku, Honshu, Sado, Hokkaido, Rishiri, Rebun) and Sakhalin, the Ryukyu Islands plus Taiwan (Tsurusaki & Shimojana, unpublished data), and the Kuril Islands (Tsurusaki & Crawford, unpublished) accompanied by regression lines and z-values of the regressions. Please note that the z-value seems to decrease with latitudes where those island groups stretch over: $z=0.30$ in the Ryukyu Islands (24°27′–30°50′), $z=0.21$, main Japanese islands plus Sakhalin (30°58′–54°30′), and $z=0.19$ in the Kuril Islands (43°40′–50°50′). These z-values are generally larger than those reported for other invertebrates such as butterflies (0.25), earthworms (0.10), ants (0.09), and close to those known for plants (0.23) (Horner-Devine et al. 2004) or *Tetragnatha* spiders in temperate regions ($z=0.26$: Gillespie & Croom 1995).

As shown in Figure 9, the numbers of species found in Is. Dôgo and Is. Chiburi fairly exceed those expected from any of the three regression lines. Moreover, those obtained for Is. Nishinoshima and Is. Nakanoshima are also larger when compared with islands with comparable size in the Ryukyus and the Kurils. This high species number in the Oki Islands may be explained by the fact that these islands abound in mountains of moderate elevation and hence afford to provide various habitats for inhabitant organisms. Another possible factor that may explain the high species number in these islands is the fact that the islands had been connected to the Shimane Peninsula during Pleistocene and had chances for the immigration from the mainland Honshu.

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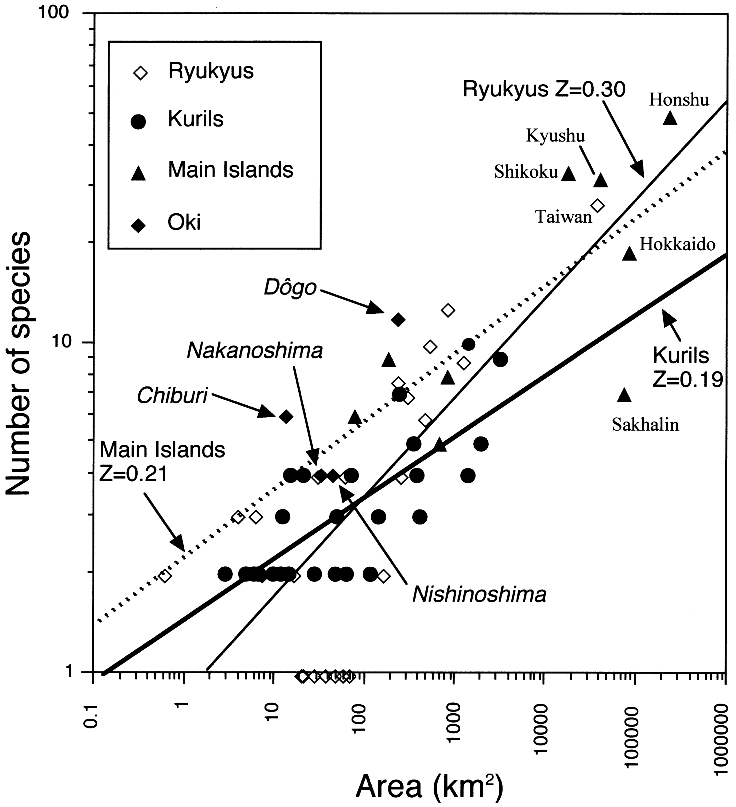

Fig. 9. Species-area relationships among islands in and around Japanese Islands based on opilionid species composition. Open diamonds: the Ryukyu Islands and Taiwan. Solid circles: the Kuril Islands. Solid triangles: Sakhalin and Main Islands of Japan accompanied with nearby smaller islands. Solid diamonds: Four main islands of the Oki Islands (Dôgo, Nishinoshima, Nakanoshima, Chiburi).

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